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BLOOD GLUCOSE LEVEL AND SERUM LIPID PROFILE OF WISTAR ALBINO RATS FED FOUR SPECIES OF LOCAL BEANS CONSUMED IN SOUTH-EAST, NIGERIA

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ABSTRACT
The glycemic and lipid profile status of Wistar albino rats fed four local species (*C. Cajan, V. unguiculata subsp. sesquipedalis, P. vulgaris* L 'Red kidney', and *P. vulgaris* 'Black turtle') commonly consumed in South-east, Nigeria was examined. The experimental design comprises of 30 male Wistar rats distributed into 5 groups of 6 rats each. The effects of the beans on the glucose level suggests that the fasting blood glucose levels was higher in the group fed *C. cajan* while Red kidney group had the least fasting blood glucose levels. The effects of the beans on the lipid profile shows that *P. vulgaris* L 'Red kidney' group had a higher serum cholesterol and HDL compared to the control while *C. cajan* had a higher LDL cholesterol than others while there was a general decrease in TG and VLDL across the group.

KEYWORDS: Glucose level, lipid profile, cholesterol, triglycerides, beans, Wistar albino rats.

1. INTRODUCTION
The relationship between glucose and lipid metabolism has been a subject of controversy when considering options available for the treatment and management of Type 2 diabetes. This relationship is best termed as diabetic dyslipidemia. Diabetes sets in when there is a problem with the hormone insulin which often results in abnormally high level of glucose in the blood[1-4], whereas dyslipidemia occur when there is abnormal levels of lipids (hyperlipidemia or hypolipedemia) such as triglycerides, low high density lipoprotein cholesterol (HDL-C), and predominance of small-dense low density lipoprotein (LDL) particles.[5] Previous study by Garvey *et al*.[6] demonstrates that insulin resistance is associated with larger very low-density lipoprotein (VLDL) particle size, smaller LDL particle size, and smaller HDL particle size. Insulin resistance can cause a decrease in tissue response to insulin stimulation which is characterized by a decrease in glycogen synthesis, a defects in uptake and oxidation of glucose and, to some extent, the ability to suppress lipid oxidation.[7] Hyperlipidemia affects glucose metabolism because elevated levels of free fatty acids induces insulin resistance and β-cell dysfunction. The mechanism by which this acts is partially understood. β-cell dysfunction could be caused by lipotoxicity, which results in impairment of glucose-stimulated insulin secretion and accelerated apoptosis. Recently, islet dysfunction and loss of insulin secretion have also been associated with alterations of plasma and islet cholesterol levels.[8] On the other hand, prolonged insulin resistance can also lead to dyslipidemia through the increased efflux of free fatty acids from adipose tissue and impaired insulin-mediated skeletal muscle uptake of free fatty acids and increase fatty acid flux to the liver.

Similarly, insulin resistance can also induce an imbalance in glucose metabolism that generates chronic hyperglycemia, which in turn triggers oxidative stress and causes an inflammatory response that leads to cell

damage. As previously stated, Taskinen[9] and Haffner[10], confirms that the changes in lipid parameters in diabetes mellitus are due to increased free fatty acid flux secondary or insulin resistance. This results when total cholesterol level exceeds 200 mg/dl, triglyceride level is ≥150 mg/dl, HDL level is < 40 mg/dl in males and less than 50 mg/dl in female and LDL ≥100 mg/dl.[11] Not only do dyslipidemia contribute to the development of Type 2 diabetes, they are also considered as potential risk factors to the pathogenesis of other metabolic syndromes such as cardiovascular diseases and obesity.[4]

Diet and life style are very important factors in the management of dyslipidemia. The lipids content of the blood is an important component for the normal function of the body. Lipid metabolism, including synthesis and and transportation is a one function of the liver.[12] Therefore, it is reasonable to expect an abnormal lipid profile in those with severe liver dysfunction.[12]

The Glycemic Index (GI) of a food which is a relative ranking of carbohydrate in foods is a useful factor in quantifying how the food affects blood glucose level. The GI of a specific food depends primarily on the quantity and type of carbohydrate it contains. Other factors such as the amount of entrapment of the carbohydrate molecules within the food, the fat and protein content of the food, the amount of organic acids (or their salts) in the food, factors in the body are of concern. This measurement can be useful in predicting how certain foods affect blood glucose level or how they could be incorporated in the diet of diabetic patients. The basic step in ascertaining this is through preliminary measurements of blood glucose level. However, certain foods are known to cause elevation of blood glucose level especially those with low fiber contents. Food such as beans (red kidney beans) contains some levels of fibre.

Beans are excellent sources of proteins (20-30%) and carbohydrates (50-60%) with fairly good sources of minerals (potassium, calcium, magnesium, phosphorus and iron salts) and vitamins (B vitamins, folate, riboflavin.[13-15] Beans contain 2-3 times more proteins than cereals and offer a more practical way of eradicating protein malnutrition than cereal based diets.[16] According to Gloria *et al*.[17], beans are important sources of macronutrient, micronutrient and antioxidant compounds with a great potential for human and animal nutrition. Legumes to which beans belongs also contain higher amount of resistant starch in comparison to cereals and tubers.[18] Resistant starch is important due to its various beneficial health properties mostly mediated by short chain fatty acids produced during its fermentation in the large intestine as they result in decrease in intestinal pH.[19] The merit of dry bean is thus attributed to its high caloric value and protein content, low concentrations of phytates and phenolic compounds (which are present in beans) that can protect against cancer and cardiovascular diseases.[20,21] There are over 40,000 species of beans in existence and some of the beans genus are the *Phaseolus, Vigna, Cajanus, Mucuna, Vicia* etc.

Cajanus Cajan (L.) Millsp. (Leguminosae) is known commonly as the pigeon pea. Other common names are red gram, congo pea, gungo pea, and no-eye pea.[22] *C. cajan* is a perennial legume which is a native of India but now found across major continents of the world such as Asia, Africa and America. In Nigeria, *C. cajan* is called “fio fio” among the Igbo ethnic group and “otiili” in Yoruba language.[23,24]

Vigna unguiculata subsp. sesquipedalis is a legume cultivated to be eaten as green pods. It is known as the yardlong bean because of its length. Other names of yardlong beans include bora, bodi, long-podded cowpea, asparagus bean, pea bean, snake bean, or Chinese long bean. In the southern part of Nigeria Igbo culture, it is referred to as “akidi” and are used as food.

The kidney bean is a variety of the common bean. Kidney beans and other beans such as pinto beans, navy beans and black beans are known scientifically as *Phaseolus vulgaris* (Debouck *et al*., 1993). Among the Igbo speaking tribe of south-eastern Nigeria, it is called ‘*Ndudu brown*’. It is named for its visual resemblance in shape and colour to a kidney. It has an indispensable value in human diet and enhances the nutritional status of low income communities. It contains high amounts of dietary fiber, starch, vitamins, minerals as well as an extensive array of phytochemicals but the most important component of nutritional significance is their high protein content which is 2-3 times that of cereal grains.

The black turtle bean is a small, shiny variety of common beans (*Phaseolus vulgaris*), which is fairly low maintenance and is normally quite easy to grow, as long as a level of basic care is provided throughout the year. It is called ‘*Ndudu black*’ in Igbo language of Nigeria. Several varietis of it exists. It is one of the least exploited legumes in Nigeria despite its level of protein and common minerals such as phosphorous and iron.[26] Information regarding the composition of black beans is still lacking.[27]

For risk factor assessment, the lipid profile test is a useful test for cardiac risk assessment to help determine an individual's risk of heart disease and to help make decisions about what treatment may be best if there is borderline or high risk. Tests in this category includes: total cholesterol tests, high density lipoprotein, low density lipoprotein, triglycerides and very low-density lipoprotein cholesterol tests. According to Biradar *et al*.[11], fasting blood glucose (FBG), post prandial blood glucose (PPBG) and glycated hemoglobin (HbA1c) are most widely used as glycemic control markers. This study evaluates the effect of four local beans on blood glucose level and lipid profile in Wistar albino rat.

2. MATERIALS AND METHOD

2.1 MATERIALS

2.1.1 Plant Materials

The four species of beans, *C. Cajan*, *V. unguiculata subsp. sesquipedalis*, *P. vulgaris L* 'Red kidney', and *P. vulgaris* 'Black turtle' (Plates 1-4) was obtained from a local market in Ihiala Local Government Area of Anambra State, Nigeria and were identified.

Plate 1: *Cajanus cajan* beans.

Plate 2: *Vigna unguiculata subsp. Sesquipedalis*

Plate 3: *P. vulgaris* 'Red kidney beans'

Plate 4: *Phaseolus vulgaris* 'Black turtle beans'

2.1.2 Animals Used for the Study

Thirty (30) matured male Wistar albino rats weighing between 150-200g was used for the study. The rats was obtained from the Animal House of the Department of Zoology and Environmental Biology, University of Nigeria, Nsukka. The rats was fed with rat pellets and water *ad libitum*. Ethical clearance was obtained from the designated ethical committee.

2.1.3 Equipment Used

The equipment used are those of the Department of Biochemistry, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra State, Nigeria; Professor John I. Ihedioha Foundation for Education and Research on Health (FERH) Laboratory and Spring Board Research Laboratory, Awka, Nigeria. They were calibrated and was in a good working state.

2.1.4 Reagents/Chemical Used

The chemicals and reagents used are of analytical grade and are products of British Drug House (BDH), England, Germany, Dermstadt, May and Baker, England, Sigma Aldrich, USA, and Quimica Clinica Applicada (QCA) HDL test kit (QCA, S.A. Spain).

2.2 METHODS

2.2.1 Preparation of Bean Feed

The beans sample were sieved to remove stones and debris after which it was washed, dried and ground to flour. This was sieved and kept in an airtight container.

2.2.2 Experimental Design

Thirty (30) male Wistar albino rats were used for the study. The rats were acclimatized for seven days with free access to feed and water. After acclimatization, they were randomly distributed into five (5) groups of 6 rats each and were fed for 3 weeks (21 days) in which analyses was done on the last day. The experimental design is illustrated below:

Group 1 (control group) was fed with 150 g of normal feed kg/body weight (b.w) each day

Group 2 was fed 50g of Normal rat feed + 100g of *P. vulgaris L* 'Red kidney' kg/b.w.

Group 3 was fed 50g of Normal rat feed + 100g of *P. vulgaris* 'Black turtle' kg/b.w.

Group 4 was fed 50g of Normal rat feed + 100g of *C. Cajan* kg/b.w.

Group 5 was fed 50g of Normal rat feed + 100g of *V. u. subsp. Sesquipedalis* kg/b.w.

2.2.3 Blood Glucose Determination

The blood glucose was determined using ACCU-CHEK Active Diabetes Monitoring Kit (Roche Diagnostics GmbH, Mannheim Germany), based on the glucose oxidase method.

Procedure: The code key of the glucometer was inserted into the code key opening and a test strip inserted to make sure that the code on the glucometer matches the code on the test strip vial. A drop of blood was placed using a capillary tube in the center of the square of the

orange pad test strip when an image of a flashing blood appears on the glucometer screen which signals that the glucometer is ready. An hour glass symbol appeared on the glucometer screen which followed after 5 seconds by the test results in g/dl.

2.2.4 Serum Lipid Profile Assay

2.2.4.1 Determination of serum total cholesterol

The enzymatic colorimetric method was adopted for the determination of serum total cholesterol.

Principle: The cholesterol is determined after enzymatic hydrolysis and oxidation of the cholesterol ester. The indicator, quinoneimine is formed from hydrogen peroxide and 4-amino antipyrinein the presence of phenol and peroxidase which is then measured at wavelength of 505nm.[28]

Procedure: Quimica Clinica Applicada (QCA) kit was used. An aliquot of 1.2 ml of the working reagent was added to a set of clean labelled test tubes and two of the test tubes were labelled "Standard 1" and "Standard 2" while another was labelled "Blank" apart from the samples to be tested that were labelled according to group names and numbers (e.g. Sample A-1, Sample A-2, Sample B-1 etc.). Then 0.012 ml of the serum sample was added to the appropriately labelled test tube, mixed well and let stand for 10 minutes at room temperature. Also, 0.012 ml of the standard was added to the each of the test tubes labelled "Standard 1" and "Standard 2", mixed well and let stand for 10 minutes at room temperature. The absorbance of the samples and standard were read against the reagent blank at 505nm.

Calculation: The cholesterol content of each of the samples was calculated using the following formula:

$$mg\ cholesterol/dl = \frac{Absorbance\ of\ sample}{Absorbance\ of\ standard} x\ 200$$

To convert to SI units: (mg/100dl) x 0.02586 = mmol/L

2.2.4.2 Determination of serum high-density lipoprotein

Serum high-density lipoprotein (HDL) were determined by the Dextran sulphate-Mg (II) method.

Principle: Low-density lipoproteins (LDL), very low density lipoproteins (VLDL) and chylomicron fractions are precipitated quantitatively by the addition of precipitant solution (dextran sulphate in the presence of magnesium acetate). After centrifugation, the cholesterol concentration in HDL fraction, which remains in the supernatant, is determined after enzymatic hydrolysis and oxidation. Then, the indicator quinoneimine formed from hydrogen peroxide and 4-aminoantipyrine in the presence of phenol and peroxidase is measured at wavelength of 505nm (Albers *et al*., 1978).

Procedure: Quimica Clinica Applicada (QCA) HDL test kit was used.0.3ml of the serum sample was added to the serum in the 1ml test tube. One drop of the precipitant solution was added to the serum in 1ml test tube mixed and let stand for 15 minutes at room temperature. Centrifuged at 3000 revolutions per minute for 10 minutes.1.2 ml of the cholesterol working reagent was added to a set of clean labelled test tubes add. Two of the test tubes were labelled "Standard 1" and "Standard 2" while another was labelled "Blank" apart from the samples to be tested that were labelled according to group names and numbers (e.g. Sample A-1, Sample A-2, Sample B-1 etc.). 0.012 ml of the supernatant derived from centrifugation of the precipitant-serum sample mixture were added appropriately to the labelled test tube, mixed well and let stand for 10 minutes at room temperature. Also 0.012 ml of the standard was added to the each of the test tubes labelled "Standard 1" and "Standard 2", mixed well and let stand for 10 minutes of room temperature. The absorbance of the samples and standard were read against the reagent blank at 505nm.

Calculations: The HDL-cholesterol content of each of the samples was calculated using the following formula:

$$mmol\ HDL - Cholesterol/L = \frac{Absorbance\ of\ sample}{Absorbance\ of\ standard} x\ 200\ x\ 1.13\ x\ 0.0259$$

2.2.4.3 Determination of serum low-density lipoprotein

Polyvinyl sulphate method for the determination of LDL-cholesterol in serum using Quimica Clinica Applicada (QCA) LDL test kit was used to determine LDL.[29]

Procedure: Accurately 0.03ml of the serum sample was added to a set of clean labeled 1ml test tubes. A drop of the precipitant solution was added to 1ml test tube. It was mixed and allowed to stand for 15 minutes at room temperature. It was centrifuged at 300 revolutions per minutes for 10 minutes. About 1ml of cholesterol working reagent wasl also added to a set of cleaned test tubes. Two of the test tube labeled Standard 1 and 2 while another test tube was label blank apart from the samples to be tested that was labeled according to the group names and numbers (e.g. Sample G1-10). Approximately 0.01ml of the supernatant derived from centrifugation of the precipitant-serum sample mixture was added to the test tube. It was mixed well and allowed to stand for 10 minutes at room temperature. Also 0.01ml of the standard was added to each of the test tubes labeled standard 1 and 2. It was mixed well and allowed to stand for 10 minutes of room temperature. Reading was taken at absorbance of the samples and standard against the reagent blank at 505nm. Cholesterol content of each supernatant was calculated using the following formular:

$$\frac{Absorbance\ of\ sample}{Absorbance\ of\ standard} x\ 200$$

LDL (mg/dl) = Total cholesterol – 1.5 x supernatant cholesterol

The result was expressed in mmol LDL-cholesterol/L (i.e. mg/dl result x 0.0259).

2.2.4.4 Determination of serum triglyceride

The glycerol-phosphate oxidase method was used for the determination of serum triglyceride.[30]

Principle: The triglycerides are determined after enzymatic hydrolysis with lipases. The indicator used was a quinineimine formed from hydrogen peroxide, 4-aminophenazone and 4-chlorophenol under the catalytic influence of peroxidase. The indicator quinoneimine was then measured at wavelength of 590nm.

Procedure: Quimica Clinica Applicada (QCA) triglyceride test kit was used. 1.2 ml of the working reagent was added to a set of clean labelled test tubes and two of the test tubes were labelled "Standard 1" and "Standard 2" while another was labelled "Blank" apart from the samples to be tested that were labelled according to group names and numbers (e.g. Sample A-1, Sample A-2, Sample B-1 etc.). 0.012 ml of the sample was added to the appropriately labelled test tube, mixed well and let stand for 10 minutes at room temperature. Also 0.012 ml of the standard was added to each of the test tubes labelled "Standard 1" and "Standard 2", mixed well and let stand for 10 minutes of room temperature. The absorbance of the samples and standard were read against the reagent blank at 590nm.

Calculations: The triglyceride content of each of the samples was calculated using the following formula:

$$mmol\ triglyceride/L = \frac{Absorbance\ of\ sample}{Absorbance\ of\ standard}\ x\ 200\ x\ 0.0113$$

2.2.4.5 Calculation of serum very-low-density lipoprotein (VLDL) and low-density lipoprotein (LDL)

Very high density lipoprotein (VLDL) cholesterol was calculated by dividing the triglyceride concentration by five (VLDL = $^1/_5$ of Triglyceride), while the low density lipoprotein (LDL)-cholesterol is calculated by subtracting HDL and VLDL from total serum cholesterol.[31,32]

2.2.5 Statistical Analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 19. One way analyses of variance were adopted for comparison, and the results were subject to post hoc test using least square deviation (LSD). $P < 0.05$ were considered significant for all the results. The data obtained were expressed as mean±SD of triplicate determinations.

3. RESULTS

3.1 Effects of the Beans Species on the Blood Glucose Level

The effects of the beans species on the Fasting blood glucose level were presented in Figure 1. The result revealed slight increase in the fasting blood glucose level compared to the control at $P < 0.05$. The highest levels of fasting blood glucose was found in the group fed *C. Cajan* (3.87±0.35 mmol/L). This is followed by the group fed *P. vulgaris* 'Black turtle' (3.72±0.65 mmol/L), *V. u. subsp. Sesquipedalis* (3.61±0.34 mmol/L), *P. vulgaris L* 'Red kidney' (3.51±0.66 mmol/L), while the least glucose levels was found in the control group (3.22±0.29 mmol/L).

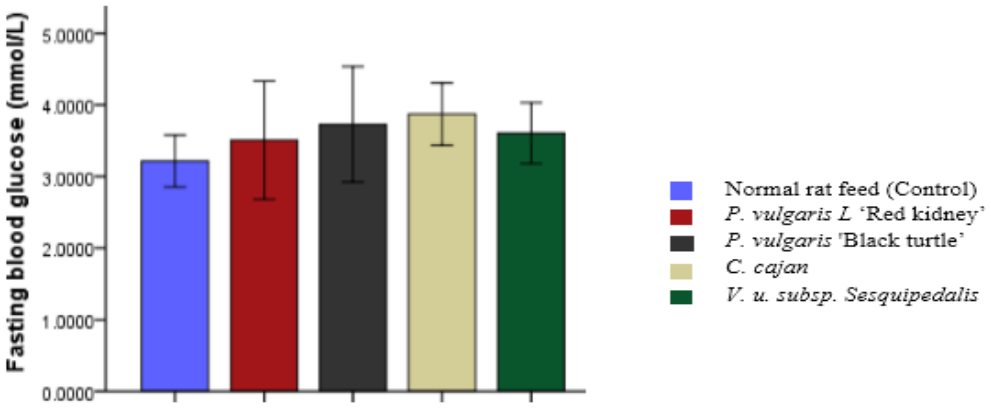

Figure 1: Effects of the beans species on the Fasting blood glucose level in Wistar albino rats.

3.2 Lipid Profile Test Results

The effects of *C. Cajan*, *V. u. subsp. sesquipedalis*, *P. vulgaris L* 'Red kidney', and *P. vulgaris* 'Black turtle' on the lipid profile (total cholesterol, HDL, LDL, triglycerides and VLDL) of Wistar albino rat were presented in Figures 2-6.

3.2.1 Effects of the Beans Species on the Serum Total Cholesterol Level

The effects of *P. vulgaris L* 'Red kidney', *P. vulgaris* 'Black turtle', *C. Cajan*, and *V. u. subsp. Sesquipedalis* on the serum total cholesterol level were presented in Figure 2. The results indicates that there was a slight

increase in the serum total cholesterol level of the group fed with *P. vulgaris L* 'Red kidney' beans (GFRKB) (1.99±0.10 mmol/L) when compared to the control (1.77±0.18 mmol/L) while no significant difference exists between other groups when compared to the control at $P < 0.05$ (*P. vulgaris* 'Black turtle' (1.68±0.11 mmol/L), *V. u. subsp. Sesquipedalis* (1.68±0.08 mmol/L), and , *C. Cajan* (1.61±0.09 mmol/L).

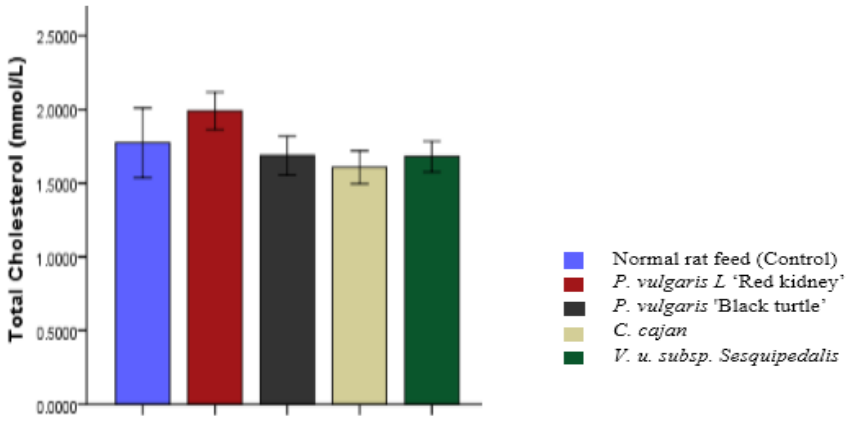

Figure 2: Effects of the beans species on the serum total cholesterol level in Wistar albino rats.

3.2.2 Effects of the Beans Species on the serum HDL Level

The effects of the local beans species on the serum HDL level were presented in Figure 3. The various groups of Wistar albino rats responded differently with no significant difference between groups fed *P. vulgaris* 'Black turtle' beans (1.29±0.07 mmol/L) at $P < 0.05$ when compared to the control (1.30±0.09 mmol/L). There was a slight increase in group fed *P. vulgaris L* 'Red kidney' (1.44±0.08 mmol/L) and a significant decrease in the group fed *C. cajan* (GFCC) (0.88±0.11 mmol/L).

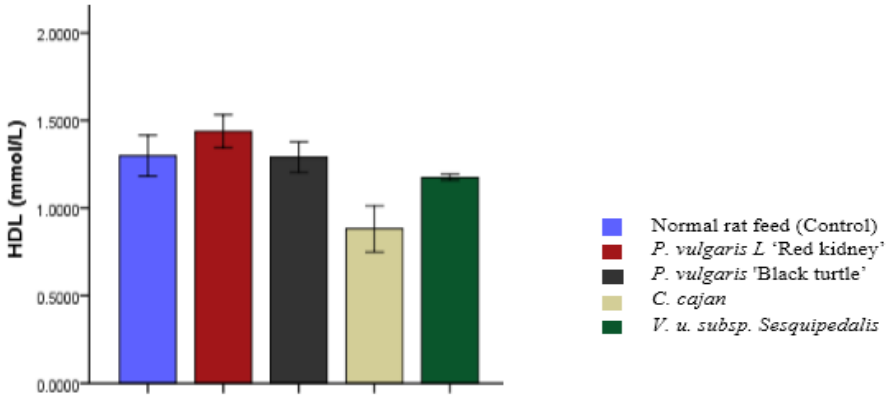

Figure 3: Effects of the beans species on the HDL level in Wistar albino rats.

3.2.3 Effects of the Beans Species on the serum LDL Level

The results of the effects of the four species of local beans on on the serum LDL level (mmol/L) were presented in Figure 4. There was a significant increase in animal groups fed with different species of beans at $P < 0.05$ when compared to the control (0.11±0.01 mmol/L). The highest response was observed in group fed with *C. cajan* (0.56±0.03 mmol/L). This is followed by the group fed *P. vulgaris L* 'Red kidney' (0.37±0.05 mmol/L), *V. u. subsp. Sesquipedalis* (0.27±0.05 mmol/L) and *P. vulgaris* 'Black turtle' (0.19±0.03 mmol/L).

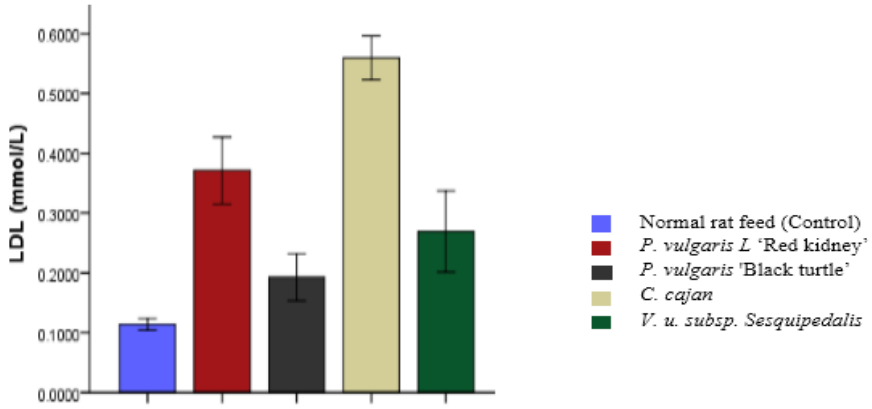

Figure 4: Effects of the beans species on the LDL level in Wistar albino rats.

3.2.4 Effects of the Beans Species on the Serum Triglycerides Level

The result obtained from the analysis of the effects of the local beans species on the serum triglycerieds levels were presented in Figure 5. There was a significant decrease at $P < 0.05$ in the serum triglycerides levels of groups fed different species of beans when compared to the control (0.77±0.04 mmol/l). The following order of decreasing concentration was observed, *V. u. subsp. Sesquipedalis* (0.48±0.03 mmol/L), *P. vulgaris L* 'Red kidney' (0.47±0.01 mmol/L), *P. vulgaris* 'Black turtle' (0.42±0.03 mmol/L) with no significant difference observed for group fed *V. u. subsp. Sesquipedalis* and *P. vulgaris L* 'Red kidney'.

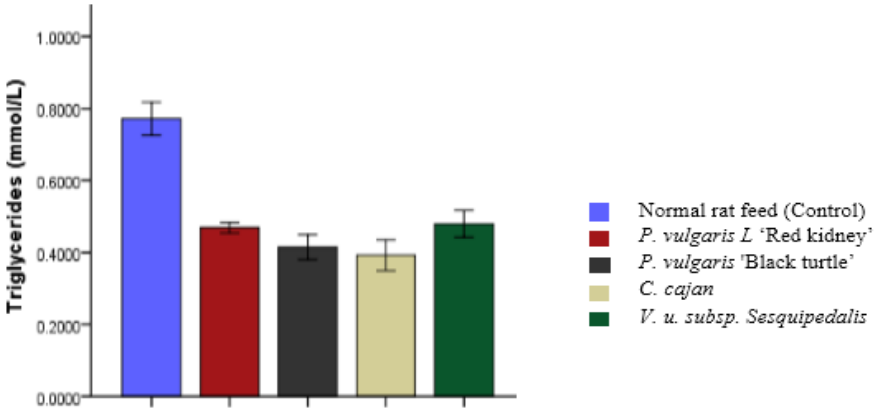

Figure 5: Effects of the beans species on the triglycerides level in Wistar albino rats.

3.2.5 Effects of the Beans Species on the serum VLDL Level

The effects of *P. vulgaris L* 'Red kidney', *P. vulgaris* 'Black turtle', *C. Cajan*, and *V. u. subsp. Sesquipedalis* on the serum VLDL level (mmol/L) were presented in Figure 6. There was a significant decrease in the VLDL level in all groups fed different beans species at $P < 0.05$ when compared to the control (0.36±0.03 mmol/L). Comparing the levels of VLDL among the groups, *P. vulgaris L* 'Red kidney' had 0.21±0.02 mmol/L with no significant difference to group fed *V. u. subsp. Sesquipedalis* (0.21±0.04 mmol/L). The group fed *C. Cajan* had the VLDL of 0.19±0.01 mmol/L while group fed *P. vulgaris* 'Black turtle' had the VLDL of 0.18±0.02 mmol/L.

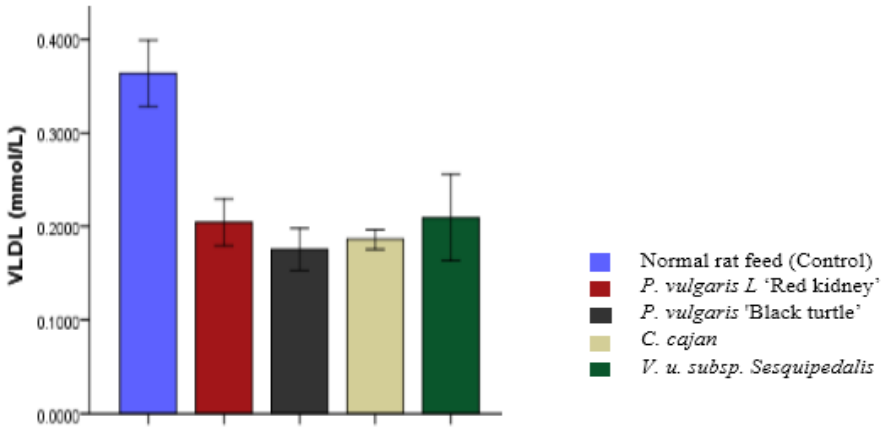

Figure 6: Effects of the beans species on the VLDL level in Wistar albino rats.

4. DISCUSSION

The effects of the bean species (*P. vulgaris L* 'Red kidney', *P. vulgaris* 'Black turtle', *C. Cajan*, and *V. u. subsp. Sesquipedalis*) supplemented in the diet of Wistar albino rats on the fasting blood glucose (FBG) level was found that there was a slight increase in the blood glucose level of the groups fed the beans species when compared to the control at $P < 0.05$ (Fig. 1). The highest level of FBG was found in the group fed *C. Cajan* (3.87±0.35 mmol/L) which was followed by the group fed *P. vulgaris* 'Black turtle' (3.72±0.65 mmol/L), *V. u. subsp. Sesquipedalis* (3.61±0.34 mmol/L), and *P. vulgaris L* 'Red kidney' (3.51±0.66 mmol/L). This findings correlates with previous studies which confirms that beans are an excellent sources of carbohydrates (50-60%) and other sources of valuable macro and micro nutrients.[13-15] However, the responses as seen in the FBG level suggests that the level of the sources of glucose or the way in which they were released varied remarkably among the beans. Also, the fact that the group fed *C. Cajan* had the highest level suggests that it may not be an ideal beans for diabetic patients because food substances highly rich in carbohydrates or to which glucose are rapidly released may cause further upsurge in blood glucose level than in decreeing or maintaining a desired threshold. This could be extended to the group fed *P. vulgaris* 'Black turtle'. Again, as seen in Figure 1, rat group fed red kidney beans exhibits the lowest level of FBG which correlates to the fact that kidney beans have high fibre content which prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes, insulin resistance or hyperglycaemia.[33]

The effects of the various bean species on the lipid profile of the rats was determined (Figs. 2-6). The results shows that there was a slight increase in the serum total cholesterol level of the group fed *P. vulgaris L* 'Red kidney' beans (1.99±0.10 mmol/L) when compared to the control (1.77±0.18 mmol/L) while no significant difference exists between other groups when compared to the control at $P < 0.05$ (Fig. 2). This result partially do not correlate with the report by Bazzano *et al*. (2003) who stated that kidney bean is a very good source of cholesterol-lowering fibre. Fibre is known to help reduce fat- cholesterol. As described by Johnson[34], fibre is basically part of plant foods- vegetables, fruits, beans, nuts, legumes, and seeds - that the body can't digest. There are two types of fiber: insoluble, which helps food pass through the digestive system, and soluble, which helps eliminate fat and lower cholesterol. The soluble fiber causes sugars and fats to enter the bloodstream at a slower rate, giving the body a steady supply of energy. When one takes foods that lack fiber, the blood sugar can spike quickly, then crashes, causing hunger and overeating. Although, since there was no significant difference in mean values, it cannot be concluded with certainty that *P. vulgaris* red kidney beans cause elevation of cholesterol. Moreover, cholesterol is needed by the body to maintain the health of the cells because it is very essential to maintain both membrane structural integrity and fluidity. In addition to its importance for animal cell structure, cholesterol also serves as a precursor for the biosynthesis of steroid hormones, bile acid and vitamin D.[35] The slight increase found in group fed with *P. vulgaris L* 'Red kidney' beans could suggests positive prospects for the beans. Although, an abnormally high levels could suggest the opposite. The effects of the beans on the HDL level shows that the various groups of Wistar albino rats responded differently with no significant difference between groups fed *P. vulgaris* 'Black turtle' beans (GFBTB) at $P < 0.05$. However, there was a slight increase in group fed *P. vulgaris L* 'Red kidney' and a decrease in the group fed *C. cajan* (GFCC). HDL particles (especially large HDL) have been identified as a mechanism by which cholesterol and inflammatory mediators can be removed from atheroma. HDL is called "good" cholesterol because it removes excess cholesterol from the blood and takes it to the liver. A high HDL level is related to lower risk of heart and blood vessel disease. Based on this, group fed *C. cajan* (GFCC) that shows slight decrease did not portray a positive effects of the beans. On the LDL assay, the same group (*C. cajan* (GFCC) Figure 4, recorded the highest LDL followed by groups fed *P. vulgaris* 'Red kidney' beans (GFRKB). LDL particles are

often termed "bad cholesterol" because they have been linked to atheroma formation since higher blood LDL, especially higher LDL particle concentrations and smaller LDL particle size, contribute to this process more than the cholesterol content of the HDL particles [36]. The triglycerides and VLDL estimation followed similar pattern. There was a general decrease across the groups compared to the control (Figs. 5-6).

5. CONCLUSION

The effects of the various species of local beans on the fasting blood glucose levels and lipid profiles suggests that the beans are valuable source of glucose and lipids. However, care must be taken in the consumption of beans such as *C. cajan*, because rat group fed it shows low level of serum HDL and then a high levels of LDL which could enhance further risks of metabolic syndrome such as cardiovascular diseases, the major cause of death in diabetic patients. However, it is recommended that diabetic patients should consume more of Red kidney beans than other beans because group fed it exhibits lower FBG level than others.

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